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FISH & GAME DEPARTMENT

Fisheries Division

TOXICITY OF EIGHT
DIFFERENT PESTICIDES TO FISH

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WATER QUALITY INVESTIGATIONS

TOXICITY OF EIGHT DIFFERENT PESTICIDES TO FISH

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Abstract

Bioassays of the following pesticides were made to test their relative toxicity to fish: (Trade names) Dowpon, Karmex W, Amino Triazole, Aquatic weed-killer, Phygon X-L, Sinox General, Malathion and Heptachlor. All of these compounds are now in use. The test fish used in all of the bioassays were Red-sided Shiners, *Richardsonius balteatus hydroflox*. Two dilutent waters with different chemical characteristics (pH, hardness and alkalinity) were used for the tests. Results obtained in the bioassays (96-hour TL_m [median tolerance limit] values) indicated that pH, alkalinity, and hardness have no major effect on the toxicity of the compounds tested. Amino triazole, Phygon X-L and Sinox General appear to be slightly more toxic in the softer tap water. Indications are that Heptachlor, Phygon X-L, Sinox General, Aquatic weed-killer, and Malathion all represent potential hazards to fish life. Karmex W, Dowpon and Amino Triazole do not appear to represent a major toxicity problem unless carelessly handled or used in overdosage.

TOXICITY OF EIGHT DIFFERENT PESTICIDES TO FISH

Introduction

The use in agriculture of certain organic herbicides and insecticides that are extremely toxic to fish presents a problem that can become serious in areas of the state where these compounds come in contact with waters containing game fish species. Indiscriminate use of these compounds in or near waters containing these species case lead to severe or even catastrophic fish kills. The introduction of these substances either directly or indirectly to public waters undoubtedly explains some of the instances of sudden fish kills reported frown time to time.

It has been reported and observed that concentrations of insecticides and herbicides greatly exceeding the recommended dosages often are applied. There should be an increased awareness of the hazards involved in their application, which should result in more judicious use of these toxicants for the control of weeds and pests.

There is a relatively meager amount of published literature available pertaining to the effects of herbicides and insecticides on aquatic life. More pertinent publications have become available recently due to the upswing of interest in these chemicals among professional conservationists.

Herbicides and insecticides are a diverse group of organic and inorganic chemicals. They are sold in many forms such as wettable powders, emulsifiable liquids, dusts, aerosols, and in the case of the older type inorganic compounds, the metal salts themselves.

Some herbicides may be used for eliminating field crop weeds, others for eliminating aquatic weeds or algae in irrigation ditches, lakes and other waters. Herbicides may attack and kill the foliage on contact, or attack the roots and kill the whole plant. Some are selective killers of weeds, others general.

Insecticides have been developed to destroy many kinds of insect pests in all types of habitat. Many of these substances are intended for applications to fields and orchards. However, they may be wafted by air or washed by rains into surface waters or leach into underground basins. In some instances the insecticides are applied directly to open water surfaces to control mosquitoe larvae.

Procedures

A review of the literature was made to become acquainted with the available information on herbicides and insecticides and their effects on aquatic life.

The toxicity bioassay methods employed are based largely on the procedures described by Doudoroff et al (1951). By means of such bio-assays, in which test animals are exposed to known concentrations of a substance for specified periods of time, the relative toxicity of a material can be determined. The index of relative toxicity used was the 48-hour and 96-hour median tolerance limit (TL_m), or the concentration at which 50 percent of the test animals survive for a period of 48 or 96 hours. The 24-hour TL_m was also recorded for all compounds tested.

The bioassays were performed in 3-gallon wide-mouth jars with 10 liters of solution. Dilutent waters used for the tests were laboratory tap water and natural water from a nearby drainage ditch. The average chemical characteristics of these waters were as follows:

	Dissolved Oxygen p.p.m.	pH	Alka-linity p.p.m.	Hard-ness p.p.m.
(1) Tap Water	9.0	7.6	36	18
(2) Ditch Water	9.0	8.2	116	156

The drainage ditch is planted each year with catchable-size rainbow trout and supports a good trout fishery. The dilutent water was allowed to stand for 48 hours in the test jars to acclimatize it to the temperature of the room (68 to 72 degrees Fahrenheit). The water was always aerated before the test was begun with pure oxygen to bring the dissolved oxygen up to the level of saturation (approximately 9 p.p.m.) Dissolved oxygen determinations, using the Winkler method, were always taken before the test was begun and at the termination of the test, or at the time all fish died in any one of the test jars.

The concentrations of test solutions used were taken from a logarithmic series recommended by Doudoroff et al (1951). Usually three concentrations were tested along with one dilutent water control, in assaying each herbicide or insecticide. The two concentrations which resulted in survivals closest above and below the 50 percent point were plotted on semi-logarithmic scale, and the survival percentages were plotted on the arithmetic scale. The concentration which resulted in a 50 percent survival was estimated from a straight line connecting the two points, which was plotted. This estimated concentration was considered to be the 24, 48, or 96-hour TL_m according to the length of time the test was run.

Red-sided shiners, Richardsonius balteatus hydroflox, (Cope) were the test fish used in the bioassays. These fish were seined at frequent intervals from a large slough along the Boise River and averaged about 6 to 7 centimeters in total length, and were approximately 1 to 1½ grams each in weight. Shiners make a desirable test species since they are often found in schools of a uniform size, are easily handled in the laboratory, usually inhabit waters also inhabited by game fish and are of intermediate tolerance to most chemicals. The fish were held in a live box in a small drain ditch near the laboratory or inside the laboratory in well aerated 3-gallon glass jars, in all cases the fish were acclimatized to the room temperature for at least 48 hours before being used in bioassays.

In each series of tests 5 fish, rather than the usual 10, were used per concentration, so that more tests could be performed in a shorter period of time. Although the experimental error is greater than if 10 fish are used, the results are still adequate for the purposes of the study.

The fish were fed a fine grain hatchery pellet food to which they seemed to adapt quite readily. Test fish to be used in a bioassay were generally not fed for two days preceding the bioassay and were not fed during the test.

Exploratory tests were made for each compound tested to determine the approximate toxic range. These solutions were prepared to cover a wide range of concentrations, from .1 to 1800 p.p.m. These were performed in the same manner as the full scale tests except for the period of time the test was run. This was usually 12 hours.

In all full-scale bioassays at least 2 and usually 3 replications were made for each chemical tested in each type of dilutent water.

The products tested were purchased from two retail concerns in the Boise Valley. As many of these products are marketed under various trade names, the organic formula is given and other common names where known.

The following herbicides, listed by trade name, were tested by bioassay, Phygon X-L, Karmex W, Aquatic weed-killer, Amino triazole, Dowpon, and Sinox General.

The following insecticides, listed by trade name, were tested by bioassay: Heptachlor, and Malathion.

Preparation of Compounds for Bioassay:

The compounds packaged as wettable powders were weighed out in milligrams per liter to obtain the concentrations in parts per million and added directly to the test water. The TL_m values obtained were then multiplied by the percentage of active ingredient in the compound to arrive at the TL_m for the active ingredient.

Dilutions were made of three of the emulsifiable solutions used, Heptachlor, Malathion, and Sinox General. These were then added to the dilutent water. The TL_m values then obtained were multiplied by the percentage of active ingredient in the formulations to arrive at the TL_m value for the active substance. Since the chemical makeup of Acquatic is unknown the TL_m values recorded are for the formulation only

Results, Discussion and Recommendations

Herbicides:

Dowpon. Dowpon, better known as Dalapon, is a herbicide manufactured by the Dow Chemical Company. The chemical name of the active ingredient is 2, 2-Dichloro-propionic Acid (Sodium salt). The compound tested was packaged as a wettable powder with 85 percent of the active ingredient. It is highly soluble in water and is generally administered directly to the plant in a spray form. Dowpon is used to control many annual grasses, as well as cattails and phragmites. It finds use along drainage ditches, marshes and non-crop lands.

Very little published literature was available on Dowpon or Dalapon concerning its toxicity to fish life. Tests performed by the Dow Chemical Company (1953) using the Lake Emerald Shiner, *Notropis atherinoides* sp., as a test fish, reported no toxicity to these fish in water containing 3000 p.p.m. of Dalapon (Sodium salt) but that all fish were killed at a concentration of 5000 p.p.m., (Springer, 1957).

The results of bioassays performed here are summarized in Tables 1 and 9, and Figure 1. These results show toxicities (48 and 96-hour TL_m's) much lower than those recorded by the Dow Chemical Company. In concentrations above 850 p.p.m. of the active ingredient, complete mortality resulted in one hour in both types of dilutent waters. The 96-hour TL_m values for both dilutent waters averaged about 330 p.p.m. More comparative tests are needed with this compound.

For most purposes it is recommended that 4 ounces of Dowpon be added to each gallon of water to be used in a spray. This forms a concentration of Dowpon in the spray tank of about 26,000 p.p.m. active ingredient.

In cases where Dowpon is used to eradicate cattails and similar plants in or around small bodies of water containing fish life, it would seem wise to use caution in spraying operations. Wasteful or careless spraying techniques resulting in large amounts of the chemical entering the water would undoubtedly be dangerous to fish life.

Karmex W. The active ingredient in this herbicide, 3-(p-chlorophenyl)-1, 1-dimethylurea (80 percent active ingredient), is better known as CMU or Monuron and is manufactured by the Dupont Corporation. Karmex is packaged as a wettable powder which forms a fine suspension in water. It is a relatively new herbicide (1952) killing various terrestrial and aquatic weeds by attacking the roots. It acts as a soil sterilant and is said by the manufacturer to give extended weed control below the water line in ditches, even after the water has been turned in. The recommended dosage for use in ponds and ditches is from 5 to 20 p,p.m.

Available literature credits CMU as being toxic to fish at concentrations of from 9 to 20 p.p.m., (Rudd and Genelly, 1956). Applications of 4.6 to 15.4 p.p.m. CMU (100 pounds per acre) in vegetated ponds appeared to cause vary little mortality to bluegills, brown bullheads, and bass, although bluegills failed to spawn, (Rudd and Genelly, 1957).

Bioassays performed in this laboratory resulted in, no mortality to shiners below 25.6 p.p.m (active ingredient) in 96 hours. Forty-eight hour and 96-hour TL_m values averaged 33 p.p.m. in tests with bath dilutent waters, (Tables 2 and 9 , and Figure 2.)

At the dosage recommended for using Karmex W there seems to be no particular toxicity problem. However, this compound should be tested with many types of fish for comparative tolerances.

Amino Triazole (Weedazol, ATA). Amino Triazole is a herbicide with 3 amin-1, 2, 4, trizole as the active ingredient. The compound tested contains 50 percent of the active ingredient and 50 percent inert ingredients, and is manufactured by the American Cyanamid Company. It is packaged as a wettable powder which is fairly soluble in water.

Amino Triazole is used to kill various perennial weeds, including cattails, tules, phragmites, and some woody plants and vines. The manufacturer recommends that the spray (composed of the compound mixed in water) be applied directly to the plant in concentrations of 6000 to 20,000 p.p.m., depending on the weed to be controlled. This herbicide prevents the plant from producing chlorophyll and generally kills the plant in two to three weeks.

In tests conducted by the Academy of Natural Science a concentration of 10,000 p.p.m. of Amino Triazole was necessary to kill one-half of the bluegills tested during a 48-hour exposure. It was stated that tests indicated that all fish would be expected to survive at a concentration of 1470 p.p.m. It is not known whether the above concentrations were for the active ingredient or the formulation. No other published literature was found concerning the action of this herbicide on aquatic life.

Concentrations of 5000 and 10,000 p.p.m. Amino Triazole (2500 and 5000 p.p.m. active ingredient) used on shiners in this laboratory caused complete mortality in 10 hours in both types of dilutent waters. Bioassays using concentrations of from 560 to 3200 p.p.m. (280 to 1600 p.p.m. active ingredient) show average 96-hour TL_m values to be about 685 p.p.m. active ingredient in the ditch water and about 492 p.p.m. active ingredient in the tap water, (Tables 3 and 9, and Figure 3).

It would appear that the greatest danger in using Amino Triazole would be in its use near small bodies of water such as farm ponds where lethal concentrations might enter the water. This could happen during the spraying of cattails especially when these plants are growing out into the water. In most instances and when used properly, Amino Triazole should be a relatively safe herbicide.

Aquatic Weed-Killer. The trade name "Aquatic" is used to designate an aromatic solvent of petroleum derivation which has been used extensively in the Boise valley to eradicate submerged aquatic weeds in irrigation laterals. This chemical is particularly deadly to several varieties of submergent pondweed of the genus Potamogeton sp. commonly referred to as "horsetail moss". The recommended dosages for eliminating these plants is about 400 to 500 p.p.m., (Hodgson, 1952).

Various aromatic solvents have been used to eradicate aquatic weeds in other parts of the country. All have different trade names; some are more toxic than others due to composition.

Milliard (1952), experimenting with two solvents, Aromatic #80 and Socal #3, found that 4.2 p.p.m. of these compounds killed 40 to 60 percent of the White Crappies tested. Dead-X, another solvent, was applied to a drainage ditch at a concentration of 185 to 200 p.p.m. and killed most caged fish within one mile of the point of introduction, however, unconfined fish were observed to flee before the chemical and certain insects were little effected, (Hewitt, 1948).

An Esso weed-killer, WS-1492, with an aromatic content of 99.5 percent applied at 250 to 350 p.p.m. killed gar, mudfish, and a few minnows, (Seale et al., 1952). According to Springer (1957) all of these petroleum solvent compounds are extremely toxic to fish at concentrations recommended for control of submerged aquatic weeds (150 - 740 p.p.m.).

A great deal of difficulty was encountered in testing this compound ("Aquatic") by bioassay. It appeared to lose toxicity quite rapidly when stored, although not as rapidly as when stored in a refrigerator. Since the compound was kept in polyethylene bottles part of the time, there is possibility that some of the samples lost some toxicity due to reaction of Aquatic with the plastic.

The first sample tested had a very noticeable yellow color and was more toxic than a later sample lacking the yellowish color. Since these samples were taken from a 50-gallon drum at different times, it is possible that there was some settling out.

Preliminary testing (12-hour exposure) to obtain an approximate toxic range resulted in much variance of toxicities. Two full scale replications, using 5 fish, and concentrations of 56, 100, and 180 p.p.m. showed 96-hour TL_m values between 56 and 100 p.p.m. in both types of dilutent waters. In every case there was complete mortality at 100 p.p.m. in 96 hours, (Tables 4 and 9, and Figure 4).

Observations of this herbicide in use were made in July, 1958, when a local spraying concern treated two small irrigation laterals. The larger of the two ditches was treated for a length of approximately two miles and contained three rough fish species, suckers, shiners, and squawfish. The chemical was introduced into the water under pressure through a pipe with several small nozzles. The solution forms a milky suspension with water. Many of the rough fish present were killed on contact. Others avoided the toxicant by swimming ahead of it. Eventually, most of these were killed when they stopped to rest in small side pockets.

After the treatment was completed the only aquatic fauna observed still alive for the length of the treated area were water striders (Gerridae). All other macro-invertebrates observed were dead. No analysis for mortality of plankton forms was made. Very probably they were also destroyed.

The next morning, approximately 20 hours after the treatment, some red-sided shiners were noted a few yards up the lateral from its confluence with a large drain ditch. No fish mortality was noted in the drain ditch itself, but this had not been checked until the following morning.

Perhaps the only redeeming features of these aromatic hydrocarbons are that they have no residual effects and are relatively inexpensive herbicides.

It is recognized that the clearing of irrigation laterals of noxious weeds is important to the farmer. The best solution, of course, is to develop a herbicide that will eliminate these weeds without the possibility of also eliminating fish. It is hoped that one will be developed shortly without prohibitive cost. Until this happens it should be emphasized that aromatic solvents should not be used where there is any chance of them reaching waters containing game fish within the range of their toxicity.

Phygon X-L. This herbicide is manufactured by the Naugatuck Division of the U. S. Rubber Corporation and has as its active ingredient a 50 percent concentration of 2, 3, dicholor-1, 4., napthoquinone. Phygon is packaged as a wettable powder which is fairly soluble in water. It was originally used as a fungicide and is still used for this purpose to some extent, but it has also found use as an algicide and as a selective killer of certain aquatic plants.

According to the manufacturer Phygon gives the best results in waters with temperatures above 65 degress Fahrenheit, a pH below 8.5 and a low salt and sulfide content. The dilutent waters used in the bioassays performed here meet these requirements fairly well.

The recommended dosages vary from .03 to .15 p.p.m. for control of algae (both blue-green and filamentous types) to .5 to .75 p.p.m. for control of submerged aquatic weeds such as water milfoil, Myriophyllum sp., toothed pondweed, Potamogeton sp., slender naiad, Naja sp., and waterweed, Anacharis sp. Since the dosages mentioned above were also given in pounds per acre it was assumed that the concentration of the powder itself was given, rather than the active ingredient.

Fitzgerald and Skoog (1954) found that concentrations of .3 to .55 p.p.m. of Phygon had no effect on fish and zooplankton in a lake treated with this compound. However, the Alabama Department of Conservation found that various species of fish were killed by concentrations of from .l to 1 p.p.m., (Springer, 1957).

Bioassays performed in this laboratory, using both types of dilutent water, show toxicities which appear to agree more closely with those results published by the Alabama Department. The highest concentration observed that was needed to kill half of the test fish in 96 hours in the harder water was about .4 p.p.m. of the solution (.2 p.p.m. active ingredient). All other tests with the harder water showed average 96-hour TL_m values of less than .4 p.p.m. (.2 p.p.m. active ingredient).

Results using the softer tap water showed even lower 96-hour TL_m values and were the same for three replications. The average 48-hour and 96-hour TL_m values were .225 p.p.m. (.1 p.p.m. active ingredient) (Tables 5 and 9, and Figure 5).

Phygon appears to be somewhat less toxic in harder water. Possibly the lake water mentioned by Fitzgerald and Skoog as being treated with Phygon for control of blue-green algae was quite hard. The results obtained would seem to show that Phygon could be used as an algicide without damage to fish if the recommended dosages were followed. However, it would not seem advisable to use Phygon to eradicate the aquatic weeds, above, (water milfoil, toothed pondweed, slender naiad, and waterweed) in waters containing game fish, especially at the recommended dosages that are needed to kill these plants. These dosages (.5 to .75 p.p.m.) could very possibly be lethal to any fish populations inhabiting the treated waters. As with many of these chemicals more work is needed on comparative tolerances of various fishes in different waters.

Sinox General (Knoxweed 55). Sinox General is one of the dinitro group of herbicides and the formulation used in the tests performed here is an emulsifiable liquid manufactured by Standard Agricultural Chemicals Inc. The active ingredients are 50 percent Di-nitro ortho secondary butyl phenol (DNOSBP) and 10 percent Di-nitro ortho secondary amyl butyl phenol. The percentages of these two compounds were added to make a 60 percent active ingredient formulation when estimated TL_m values.

Although this compound has been used as a dormant spray in orchard aphid and mite control, it is more commonly used as a herbicide for the control of various terrestrial weeds and grasses. It may be used for the clearing of weeds along fence rows, ditch banks, roadsides, and railroad rights-of-way.

Spray emulsions of this compound are prepared within the spray tank by adding varying amounts of oil and water. The oil may be diesel or any other inexpensive oil and is used mainly as a wetting or penetrating agent. Sinox is a contact weed killer killing foliage on contact,

There seems to be very little published literature available concerning the effects of Sinox on aquatic life. Rudd and Genelly (1956) report no losses of wildlife recorded resulting from the use of DNOSBP and apparently they believe no hazard exists. Other di-nitro compounds such as Dinitro-ortho cresol (DNOC) and 2,4,-dinitro-6-cyclo-hexylphenel (DNCHP) are known to be quite toxic to aquatic life, (Springer, 1957).

Results of bioassays performed here with the two types of dilutent waters are shown in Tables 6 and 10, and Figure 6. Average toxicities of the active ingredient, approximately .2 p.p.m., in the harder water and .1 p.p.m. in the softer water (96-hour TL_m values) indicates sufficient hazard to fish to warrant extreme caution in the use of this compound. Due to its present cost (about $10.00 per gallon) it is probably not as commonly used as better-known weedkillers such as 2, 4-D and its derivitives. Sinox decomposes fairly rapidly, therefore having no residual effects. There appears to be some lessening of toxicity in the harder ditch water as compared to the softer tap water.

Insecticides;

Heptachlor. Heptachlor is the trade name of a chlorinated hydrocarbon insecticide with the organic formula of Heptachlore-4,7-Methano-tetrahydroindene. This compound is a refined ingredient of chlordane, another widely-used insecticide. Heptachlor is formulated in dusts, wettable powders, emulsifiable concentrates, and granules.

The preparation used in these laboratory tests was an emulsifiable concentrate containing 23.3 percent Heptachlor, 62 percent of an aromatic petroleum derivitive solvent, 9 percent related compounds and 5.7 percent inert ingredients. It is manufactured by the Diamond Black Leaf Company.

Heptachlor and Chlordane are both used for killing grasshoppers as well as mosquitoes, ants, alfalfa weevils and other insect pests. Heptachlor is quite toxic to warmblooded animals, (Rudd and Genelly, 1956). Recently this compound, together with another chlorinated hydrocarbon insecticide, Dieldrin, was used to help control the fireant in the South and a good deal of adverse publicity has resulted from these applications due to wildlife losses, (The National. Audubon Society, 1958).

According to Rudd and Genelly (1956), Heptachlor is considered to be more toxic than Chlordane and the emulsifiable concentrate is considered more toxic than a wettable powder formulation. The recommended dosage is from one-fourth to one and one-half gallons of emulsifiable concentrate per acre.

Rudd and Genelly report that in trials with trout fingerlings, toxicity for Heptachlor lies within the range of Chlordane and Aldrin (0.5 to .05 p.p.m.) with a Heptachlor emulsifiable concentrate. Henderson, Pickering, and Tarzwell (1958), using a solid form of Heptachlor dissolved in an organic solvent (acetone), with a composition of 72 percent Heptachlor and 28 percent related compounds, report a 96-hour TL_m value of .056 p.p.m. (active ingredient) for fathead minnows in very hard water (400 p.p.m.) and a 96-hour TL_m value of .093 p.p.m. (active ingredient) in soft water (20 p.p.m.). Other fish used in order of increasing sensitivity were guppies, goldfish and bluegills. It was concluded by these investigators that pH, hardness and alkalinity have no major effect on the toxicities of chlorinated hydrocarbons.

Results of bioassays performed in this laboratory with the two dilutent waters are shown in Tables 7 and 9, and Figure 7. These results show an average 96-hour TL_m of .11 p.p.m. (active ingredient) for the hard water and an average 96-hour TL_m value of .09 p.p.m. (active ingredient) for the softer water.

From this it may be concluded that concentrations of Heptachlor normally applied to land areas for insect control would be extremely toxic to fish life if allowed to reach waters containing them.

<u>Malathion</u>. Malathion is one of the organic phosphorous insecticides with the imposing chemical name of O,o-dimethyl dithiophosphate of diethyl mercaptosuccinate. The formulation used here with a 57 percent emulsifyable concentrate manufactured by the American Cyanamid Company. Malathion may also be sold as a wettable powder, dust, or in aerosol form. It is used often as the main ingredient in household bug bombs, and has been found to be deadly to DDT-resistant houseflies, (Rudd and Genelly, 1956). Malathion has been used with good effect on mosquitoe larvae in ponds

and sloughs. The rates of application range from 0.5 to 1.5 pounds per acre, (Rudd and Genelly, 1956).

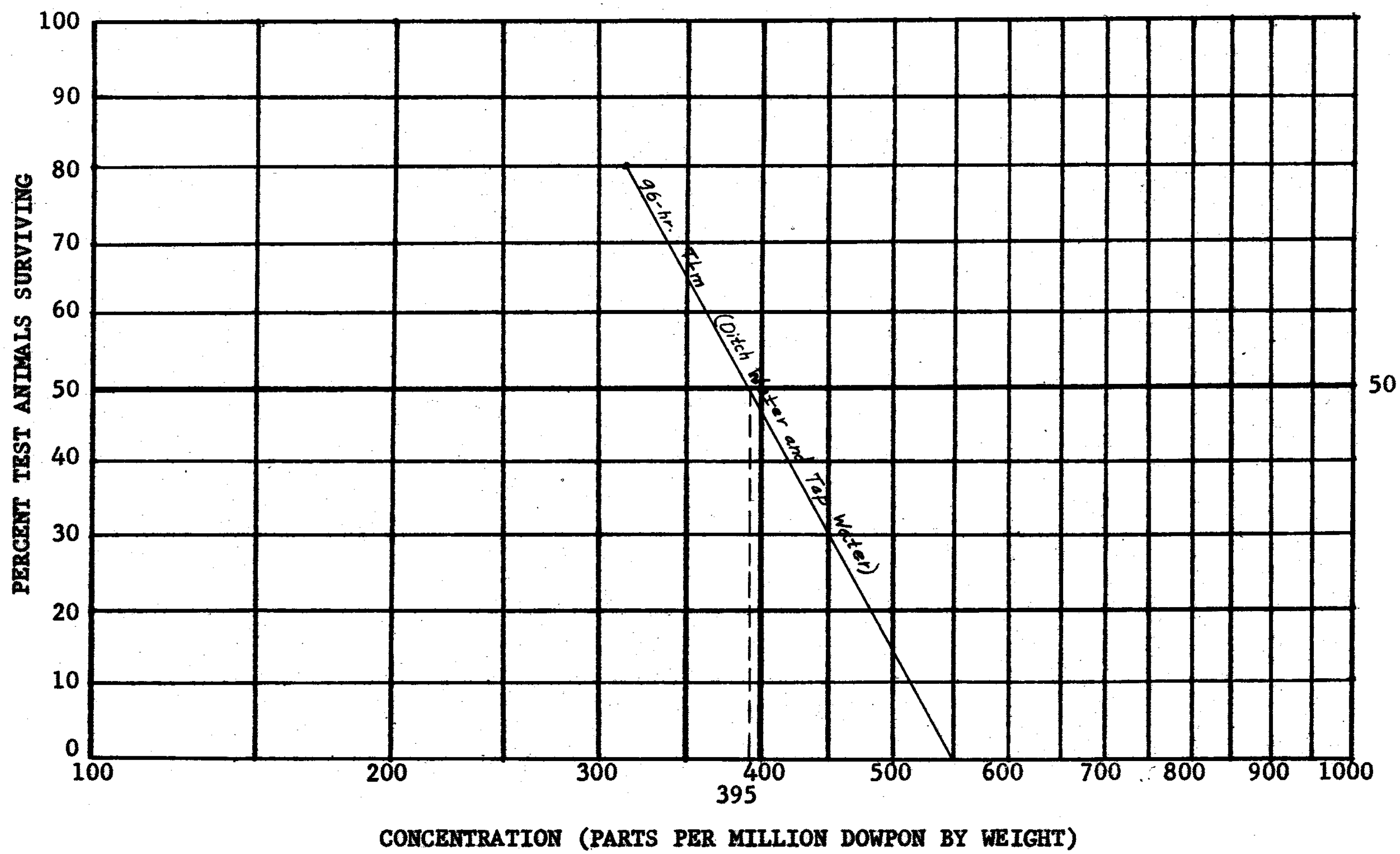
Tests performed by Parkhurst and Johnson (1955) using Malathion 500 and chinook salmon fingerlings, <u>Oncorhynchus</u> <u>tschawytscha</u>, as test animals, report a 96-hour TL_m value of .12 p.p.m. These tests indicated that the toxicity of the emulsion was not altered by remaining in water up to six days before the introduction of test fish. This speaks quite highly for the residual effect of Malathion. Henderson and Pickering (1956) report 96-hour TL_m values of 12.5 p.p.m. Malathion (active ingredient) using a 57 percent emulsifiable concentrate. The same TL_m value was obtained using both soft and very hard dilutent waters and fathead minnows, <u>Pimehpales</u> <u>promelas</u> as the test fish.

Bioassay results for Malathion axe presented in Tables 8 and 9, and Figure 8. Median tolerance limit (TL_m) values for 96 hours of 12.8 p.p.m. and 9.5 p.p.m. (active ingredient) for the soft water and hard water respectively were obtained using red-sided shiners as test fish. The wide variance with Parkhurst and Johnson's results show possibly a greater tolerance by shiners than by chinook salmon, at least with Malathion. The difference in toxicity of Malathion in the two dilutent waters does not appear to be significant within the range of experimental error that may be expected in bioassays using 5 fish. Henderson and Pickering (1956) show no difference in TL_m values using 10 fish.

According to Rudd and Genelly (1956), Malathion is the safest of the organic phosphate insecticides now in use. However, this is not necessarily a recommendation for using it indiscriminately. Malathion is toxic enough to fish that it would definitely be a hazard if introduced into waters in sufficient quantities. It has been considered as a substitute for rotenone for fish eradication by some investigators.

Figure 1

Estimation of median tolerance limits for Dowpon
by straight-line graphical interpolation
(Data derived from Replication 1, Table 1)



395 x .85 = 336 p.p.m. active ingredient

Figure 2

Estimation of median tolerance limits for Karmex W
by straight-line graphical interpolation
(Data derived from Replication 1, Table 2)

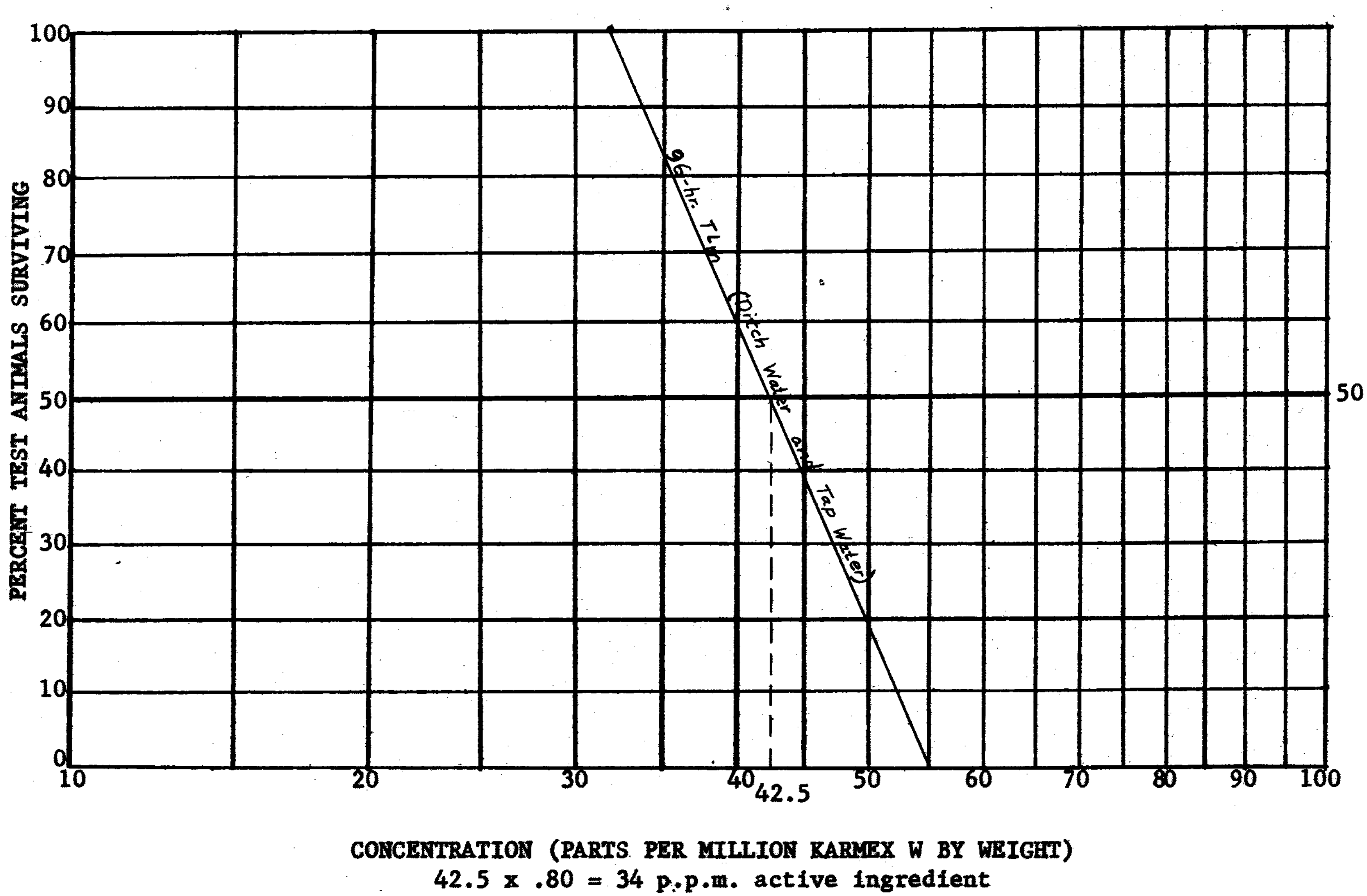
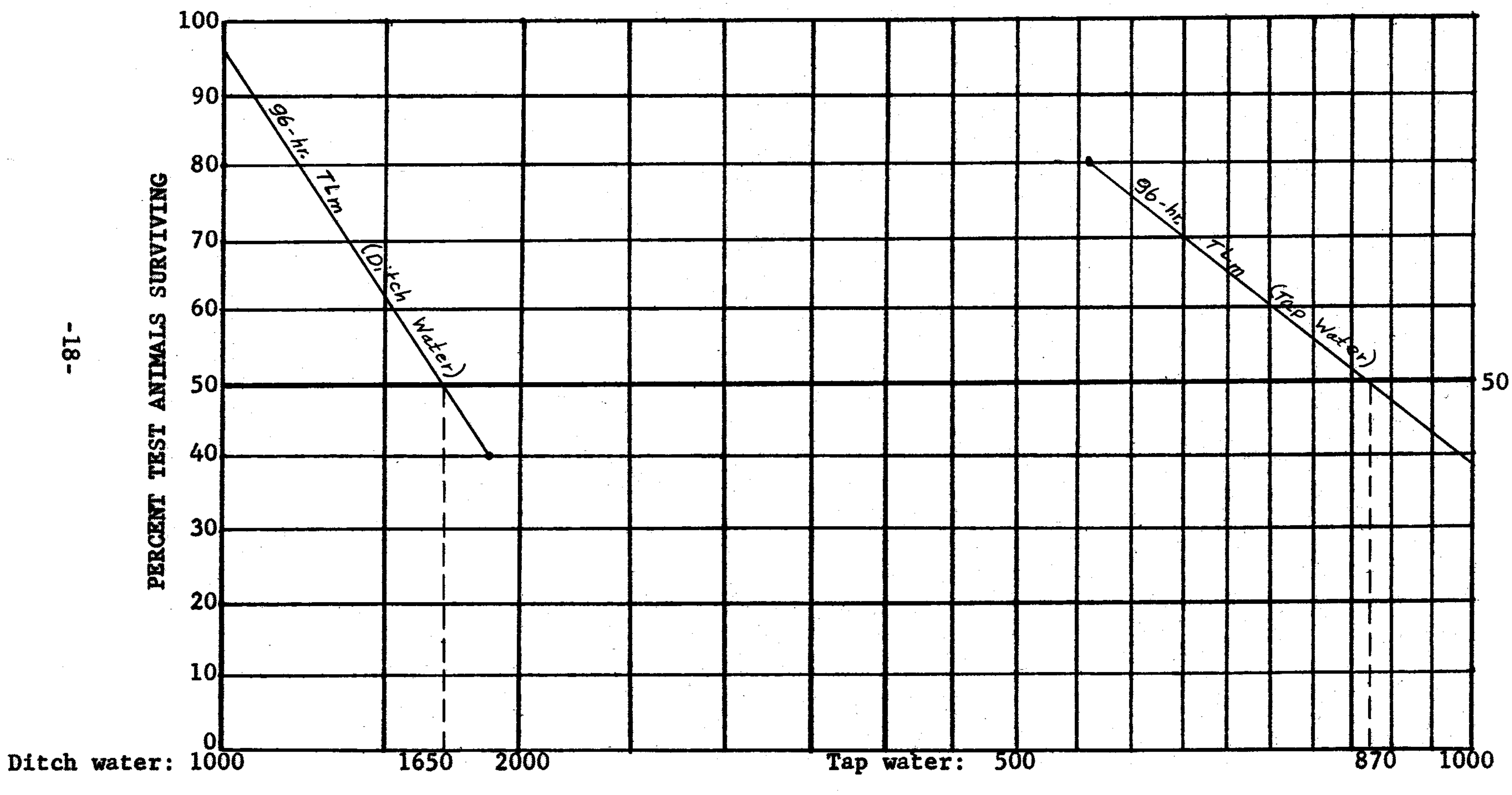


Figure 3

Estimation of median tolerance limits for ATA
by straight-line graphical interpolation
(Data derived from Replication 1, Table 3)



1650 x .50 = 825 p.p.m. active ingredient   870 x .50 = 435 p.p.m. active ingredient

Figure 4

Estimation of median tolerance limits for Aquatic
by straight-line graphical interpolation
(Data derived from Replication 1, Table 4)

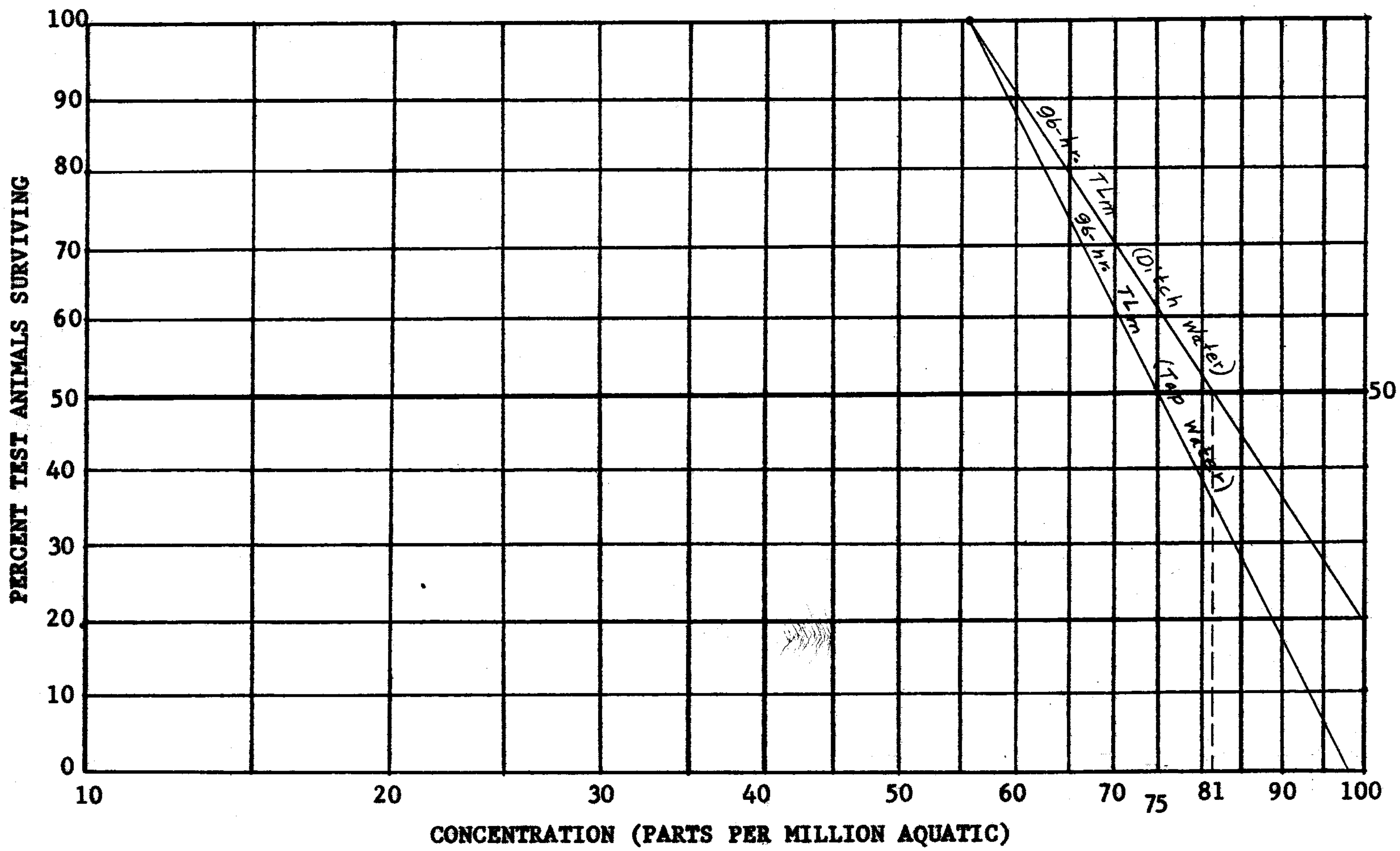
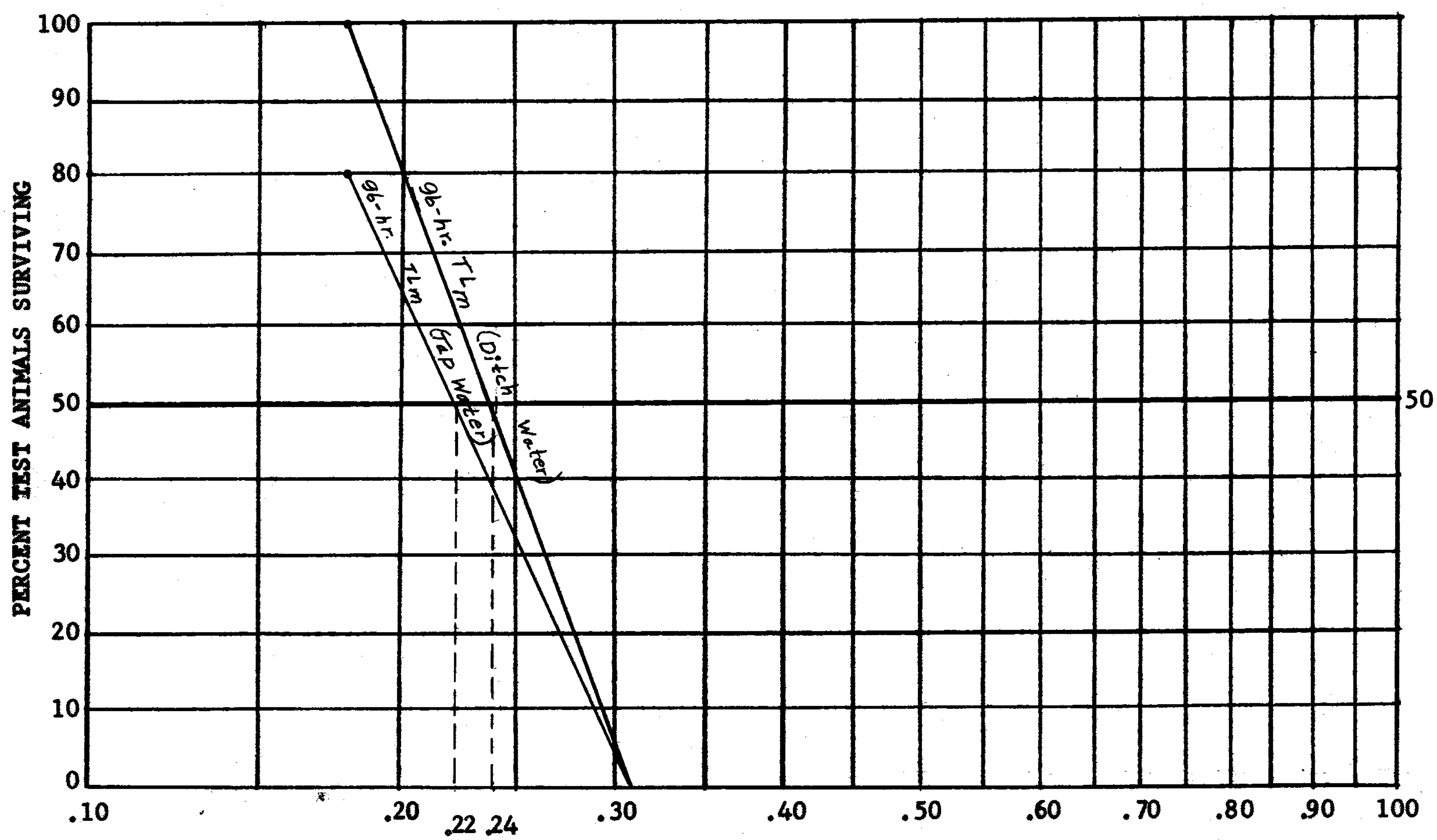


Figure 5

Estimation of median tolerance limits for Phygon X-L
by straight-line graphical interpolation
(Data derived from Replication 1, Table 5)

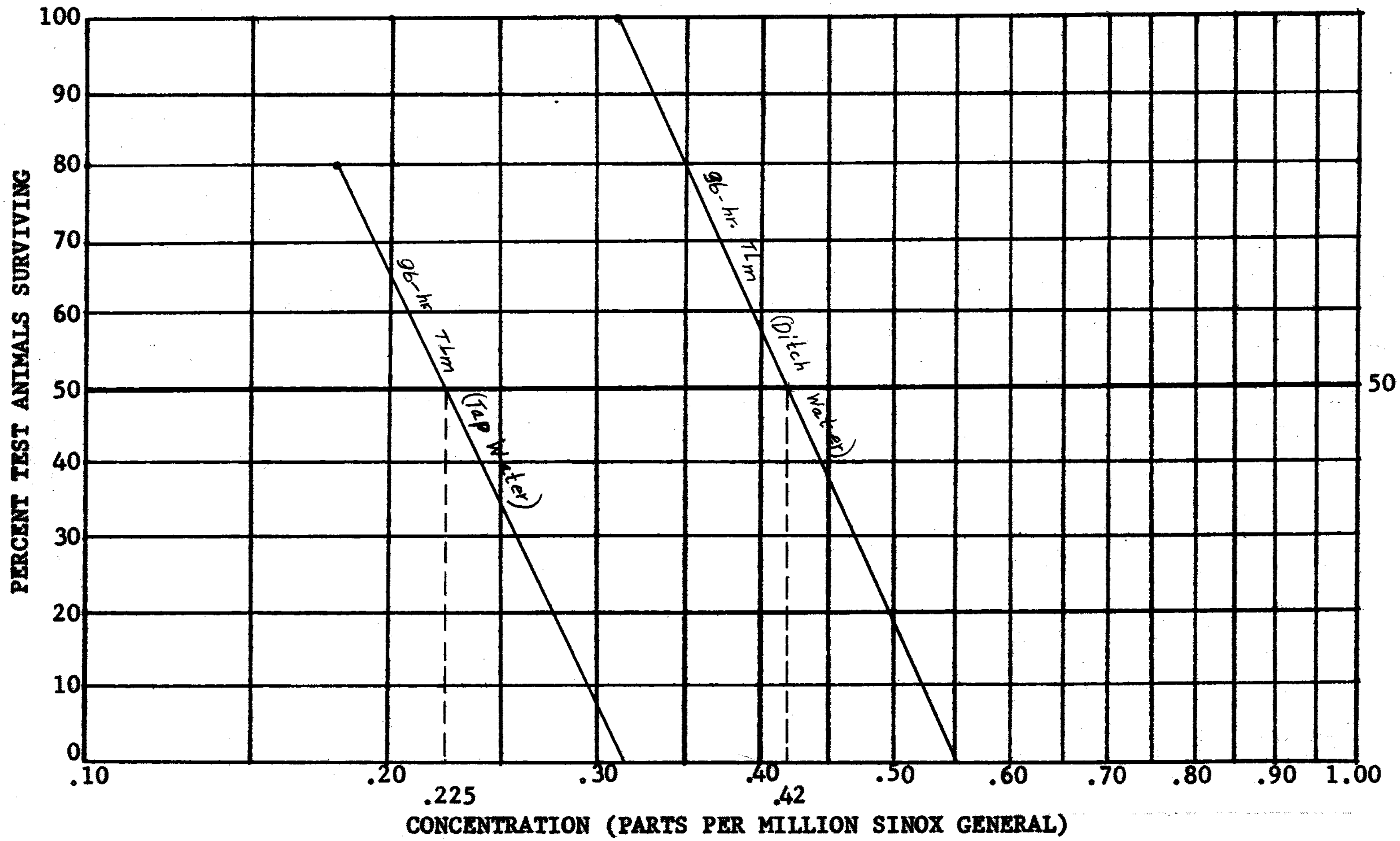


CONCENTRATION (PARTS PER MILLION PHYGON BY WEIGHT)

.22 x .50 = .11 p.p.m. active ingredient   .24 x .50 = .12 p.p.m. active ingredient

Figure 6

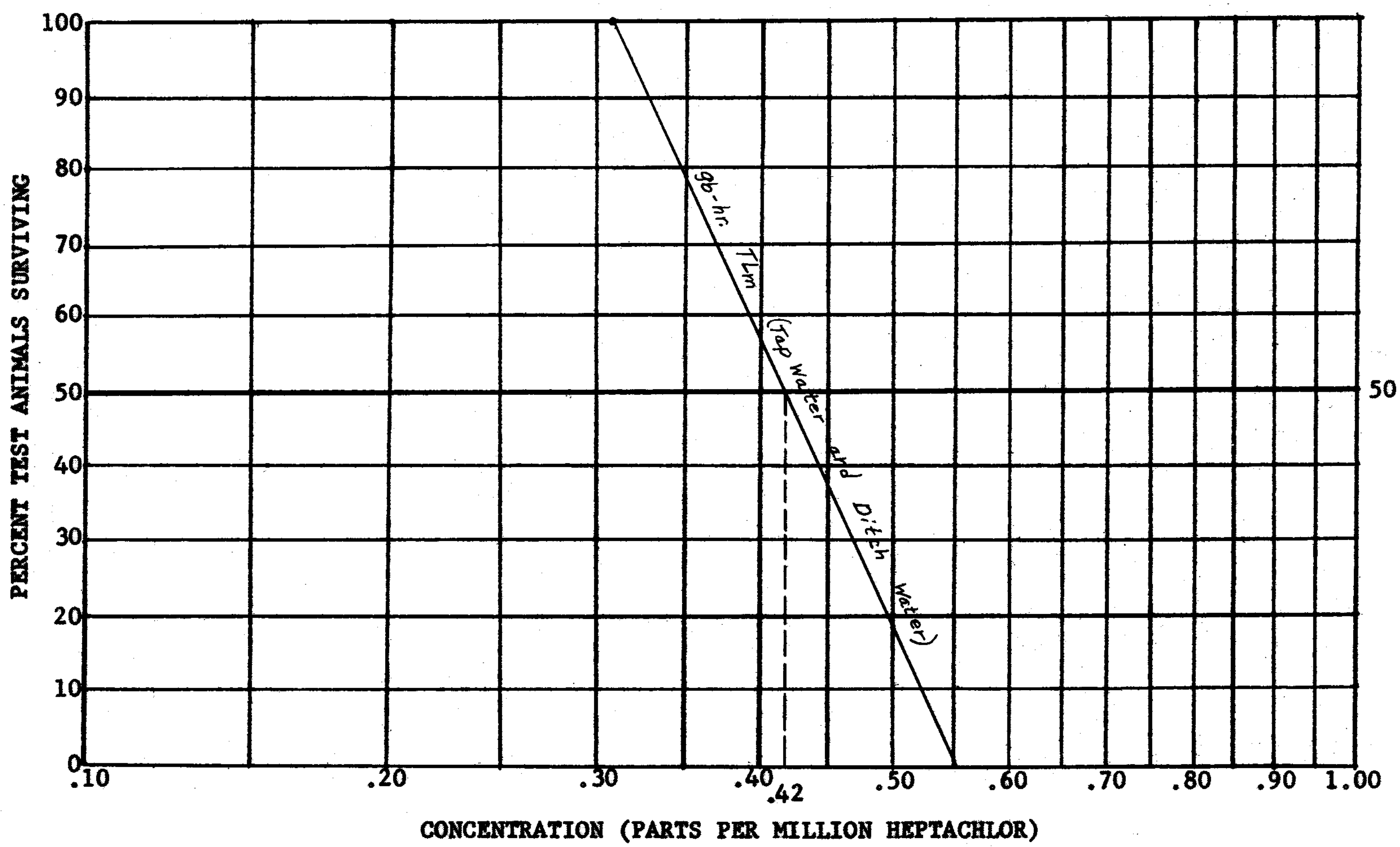
Estimation of median tolerance limits for Sinox General
by straight-line graphical interpolation
(Data derived from Replication 1, Table 6)



.225 x .60 = .135 p.p.m. active ingredient .42 x .60 = .250 p.p.m. active ingredient

Figure 7

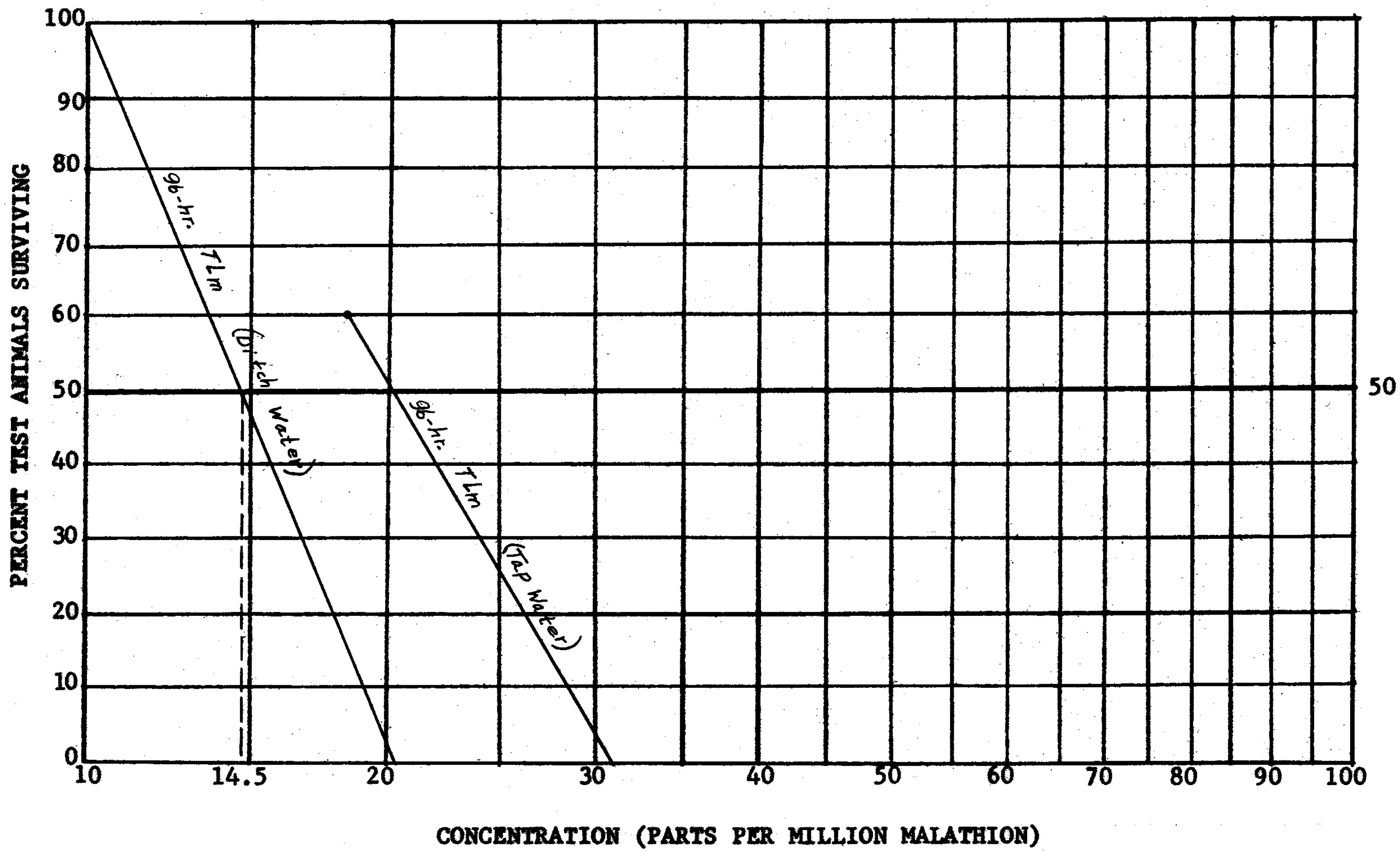
Estimation of median tolerance limits for Heptachlor
by straight-line graphical interpolation
(Data derived from Replication 1, Table 7)



.42 x .233 = .09 p.p.m. active ingredient

Figure 8

Estimation of median tolerance limits for Malathion
by straight-line graphical interpolation
(Data derived from Replication 1, Table 8)



20 x .57 = 11.4 p.p.m. active ingredient   14.5 x .57 = 8.3 p.p.m. active ingredient

Table 1

Percent Survival of Test Animals at Certain Concentrations of Dowpon

	Type of Dilutent	Conc. of Dowpon (p.p.m.)	24-hour Survival (Percent)	48-hour Survival (Percent)	96-hour Survival (Percent)	TL_m (p.p.m. active ingred.)
1.	Soft Water	560	20	0	0	24-hr. 387
		320	100	100	80	48-hr. 357
		180	100	100	100	96-hr. 336
	Hard Water	560	0	0	0	24-hr. 357
		320	100	100	80	48-hr. 357
		180	100	100	100	96-hr. 336
2.	Soft Water	560	20	0	0	24-hr. 387
		320	100	100	80	48-hr. 357
		180	100	100	100	96-hr. 336
	Hard Water	560	0	0	0	24-hr. 336
		320	80	60	60	48-hr. 302
		180	100	100	100	96-hr. 302
3.	Soft Water	560	20	0	0	24-hr. 357
		320	80	80	80	48-hr. 336
		180	100	100	100	96-hr. 336
	Hard Water	560	20	0	0	24-hr. 387
		320	100	100	100	48-hr, 357
		180	100	100	100	96-hr. 357

Table 2

Percent Survival of Test Animals at Certain Concentrations of Karmex W

	Type of Dilutent	Conc. of Dowpon (p.p.m.)	24-hour Survival (Percent)	48-hour Survival (Percent)	96-hour Survival (Percent)	TL_m (p.p.m. active ingred.)
1.	Soft Water	56	4	0	0	24-hr. 34
		32	100	100	100	48-hr. 34
		18	100	100	100	96-hr. 34
	Hard Water	56	40	20	0	24-hr. 44.8
		32	100	100	100	48-hr. 36.4
		18	100	100	100	96-hr. 34.0
2.	Soft Water	56	0	0	0	24-hr. 34
		32	100	100	100	48-hr. 34
		18	100	100	100	96-hr. 34
	Hard Water	56	60	0	0	24-hr.>56
		32	100	60	60	48-hr. 28.4
		18	100	100	100	96-hr. 28.4
3	Soft Water	56	0	0	0	24-hr. 34.0
		32	100	80	80	48-hr. 31.6
		18	100	100	100	96-hr. 31.6
	Hard Water	56	40	0	0	24-hr. 40.8
		32	100	100	100	48-hr. 34.0
		18	100	100	100	96-hr. 34.0

Table 3

Percent Survival of Test Animals at Certain Concentrations of Amino Triazole

	Type of Dilutent	Conc. of Dowpon (p.p.m.)	24-hour Survival (Percent)	48-hour Survival (Percent)	96-hour Survival (Percent)	TL_m (p.p.m. active ingred.)
	Soft	1800	0	0	0	24-hr. 560
	Water	1000	60	60	40	48-hr. 560
		560	80	80	80	96-hr. 435
1.						
	Hard	1800	80	80	40	24-hr.>1800
	Water	1000	100	100	100	48-hr.>1800
		560	100	100	100	96-hr. 825
	Soft	1800	0	0	0	24-hr. 560
	Water	1000	60	60	40	48-hr. 560
		560	100	100	100	96-hr. 480
2.						
	Hard	1800	80	60	40	24-hr.>1800
	Water	1000	100	100	100	48-hr.>1800
		560	100	100	100	96-hr. 825
	Soft	1800	0	0	0	24-hr. 875
	Water	1000	100	80	60	48-hr, 625
		560	100	100	80	96-hr. 560
3.						
	Hard	1800	80	80	0	24-hr.>1800
	water	1000	80	80	20	48-hr.>1800
		560	100	100	100	96-hr. 405

Table 4

Percent Survival of Test Animals at Certain Concentrations of Aquatic Weed-Killer

	Type of Dilutent	Conc. of Dowpon (p.p.m.)	24-hour Survival (Percent)	48-hour Survival (Percent)	96-hour Survival (Percent)	TL_m (p.p.m. active ingred.)
1.	Soft Water	180	0	0	0	24-hr. 75
		100	0	0	0	48-hr. 75
		56	100	100	100	96-hr. 75
	Hard Water	180	0	0	0	24-hr. 91
		100	40	40	20	48-hr. 91
		56	100	100	100	96-hr. 81
2.	Soft Water	180	0	0	0	24-hr. 91
		100	40	0	0	48-hr. 15
		56	100	100	100	96-hr. 75
	Hard Water	180	0	0	0	24-hr, 81
		100	20	0	0	48-hr. 75
		56	100	100	100	96-hr. 75

Table 5

Percent Survival of Test Animals at Certain Concentrations of Phygon X-L

	Type of Dilutent	Conc. of Dowpon (p.p.m.)	24-hour Survival (Percent)	48-hour Survival (Percent)	96-hour Survival (Percent)	TL_m (p.p.m. active ingred.)
1.	Soft Water	.32	60	0	0	24-hr.>.16
		.18	100	80	80	48-hr. .11
		.10	100	100	100	96-hr. .11
	Hard Water	.56	0	0	0	24-hr. .12
		.32	0	0	0	48-hr. .12
		.18	100	100	100	96-hr. .12
2.	Soft Water	.32	0	0	0	24-hr. .12
		.18	100	80	80	48-hr. .11
		.10	100	100	100	96-hr. .11
	Hard Water	.56	0	0	0	24-hr. .13
		.32	20	0	0	48-hr. .12
		.18	100	100	100	96-hr. .12
3.	Soft Water	.32	0	0	0	24-hr. .12
		.18	100	100	80	48-hr. .12
		.10	100	100	100	96-hr. .11
	Hard Water	1.00	0	0	0	24-hr. .20
		.56	0	0	0	48-hr. .20
		.32	80	80	60	96-hr. .18
		.18	100	100	100	

Table 6

Percent Survival of Test Animals at Certain Concentrations of Sinox General

	Type of Dilutent	Conc. of Dowpon (p.p.m.)	24-hour Survival (Percent)	48-hour Survival (Percent)	96-hour Survival (Percent)	TL_m (p.p.m. active ingred.)
	Soft Water	.56	0	0	0	24-hr. .14
		.32	0	0	0	48-hr. .14
1.		.18	100	100	80	96-hr. .135
	Hard Water	.56	0	0	0	24-hr. .25
		.32	100	100	100	48-hr. .25
		.18	100	100	100	96-hr. .25
	Soft Water	.56	0	0	0	24-hr. .17
		.32	40	0	0	48-hr. .14
2.		.18	100	100	100	96-hr. .14
	Hard Water	.56	0	0	0	24-hr. .24
		.32	80	80	80	48-hr. .24
		.18	100	100	100	96-hr. .24
	Soft Water	.56	0	0	0	24-hr. .16
		.32	20	0	0	48-hr. .13
3.		.18	100	80	80	96-hr. .135
	Hard Water	.56	0	0	0	24-hr. .24
		.32	80	80	80	48-hr. .24
		.18	100	80	80	96-hr. .24

Table 7

Percent Survival of Test Animals at Certain Concentrations of Heptachlor

	Type of Dilutent	Conc. of Dowpon (p.p.m.)	24-hour Survival (Percent)	48-hour Survival (Percent)	96-hour Survival (Percent)	TL_m (p.p.m. active ingred.)
1.	Soft Water	.56	60	0	0	24-hr. >.13
		.32	100	100	100	48-hr. .09
		.18	100	100	100	96-hr. .09
	Hard Water	.56	100	20	0	24-hr. .13
		.32	100	100	100	48-hr. .10
		.18	100	100	100	96-hr. .09
2.	Soft Water	.56	60	20	0	24-hr.> .13
		.32	100	100	100	48-hr. .11
		.18	100	100	100	96-hr. .09
	Hard Water	.56	80	0	0	24-hr. .13
		.32	100	100	100	48-hr. .09
		.18	100	100	100	96-hr. .09
3.	Soft Water	.56	80	40	20	24-hr.>.13
		.32	100	100	100	48-hr. .12
		.18	100	100	100	96-hr. .11
	Hard Water	1.00	20	0	0	24-hr. .18
		.56	100	80	80	48-hr. .16
		.32	100	100	100	96-hr. .16
		.18	100	100	100	

Table 8

Percent Survival of Test Animals at Certain Concentrations of Malathion

	Type of Dilutent	Conc. of Dowpon (p.p.m.)	24-hour Survival (Percent)	48-hour Survival (Percent)	96-hour Survival (Percent)	TL_m (p.p.m. active ingred.)
1.	Soft Water	32	0	0	0	24-hr. 13.6
		18	100	60	60	48-hr. 11.4
		10	100	100	100	96-hr. 11.4
	Hard Water	32	0	0	0	24-hr. 12.8
		18	80	20	20	48-hr. 8.3
		10	100	100	100	96-hr. 8.3
2.	Soft Water	32	0	0	0	24-hr. 13.6
		18	100	60	0	48-hr. 11.4
		10	100	100	100	96-hr. 7.7
	Hard Water	32	20	0	0	24-hr. 14.8
		18	100	80	80	48-hr. 12.8
		10	100	100	100	96-hr. 12.8
3.	Soft Water	32	0	0	0	24-hr. 13.6
		18	100	60	0	48-hr. 11.4
		10	100	100	100	96-hr. 7.6
	Hard Water	32	0	0	0	24-hr. 7.6
		18	0	0	0	48-hr. 7.6
		10	100	100	100	96-hr. 7.6

Table 9

Comparison of the Toxicity of Herbicides and Insecticides to Shiners in Drain Ditch Water and Tap Water

Name	Kind of Water	No. of Replications	Average TL_m (p.p.m..) 24-hrs.	48-hrs.	96-hrs.
Dowpon	Soft	3	377	350	336
	Hard	3	360	339	331
Karmex W	Soft	3	34	33.2	33.2
	Hard	3	45.8+	33.0	32.1
ATA	Soft	3	665	581	492
	Hard	3	>1800	>1800	685
Aquatic	Soft	2	83	75	75
	Hard	2	57	83	78
Phygon X-L	Soft	3	.13+	.11	.11
	Hard	3	.15	.15	.14
Sinox	Soft	3	.16	.14	.13
	Hard	3	.24	.24	.24
Heptachlor	Soft	3	> .13	.11	.096
	Hard	3	.15	.12	.11
Malathion	Soft	3	13.6	11.4	8.9
	Hard	3	11.7	9.6	9.6

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May 26, 1959

By________________________________
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LITERATURE CITED

Doudoroff, P., _et_ _al_
1951 Bioassay methods for the evaluation of acute toxicity of industrial wastes to fish. Sewage and Industrial Wastes, Vol. 23, No. 11, pp. 1380-1397.

Fitzgerald, G. P. and F. Skoog
1954. Control of blue-green algae blooms with 2,3-dichloronaphthoquinone. Sewage and Industrial Wastes, Vol. 26, No. 9, pp. 1136-1140.

Henderson, C. and Q. H. Pickering
1956. Toxicity of organic phosphorus insecticides to fish. Transactions of the American Fisheries Society, Vol. 87, (1957), pp. 39-51.

Henderson, C., Q. H. Pickering, and C. M. Tarzwell
1958. The relative toxicity of ten chlorinated hydrocarbon insecticides to four species of fish. Mimeo. 34 pp. (To be presented in The Transactions of the American Fisheries Society, (1959).

Hewitt, G. S.
1948. Effect of "Dead X" on plant and animal life. U. S. Dept. Int., Fish and Wildlife Service, Missouri River Basin Studies, unpubl. rept. 5 p.

Hilliard, D. K.
1952. The effects of herbicides and related compounds on fish. Master of Science thesis, Oregon State College. 98 pp.

Hodgson, J. M.
1952. Aromatic solvents control water weeds in irrigation laterals, University of Idaho, College of Agriculture, Extension circular No. 123. September.

Parkhurst, Z. E. and H. E. Johnson
1955. Toxicity of Malathion 500 to fall Chinook salmon. Progressive Fish Culturist, Vol. 17, No. 3, pp. 112-116.

Rudd, R. L. and R. E. Genelly
1956. Pesticides, their use and toxicity in relation to wildlife. Game Bulletin No. 7, California Department of Fish and Game. 209 pp.

Seale, C. C., J. W. Randolph, and J. C. Stephens
1952. Aromatic solvents for the control of the submerged water weed naiad, _Najas_ _guadalupensis_ (Spring) Morong., in south Florida. Weeds, Vol. 1, No. 4. pp. 366-371.

Springer, Paul F.
1957. Effects of herbicides and fungicides on wildlife. Reprinted from North Carolina Pesticide Manual, North Carolina State College. pp. 87-106.

The National Audubon Society
1958. The hazards of broadcasting toxic pesticides. Mimeo. 16 pp.